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ABSTRACT

To help evaluate driver education, 50 individuals were tested and trained by means of a simulation technique to determine if drivers could be taught to make accurate last minute passing judgments, and if knowledge of direction and magnitude of error on individual trials would have any influence on this training. In a projection room, each subject watched as the camera car he was supposedly driving actually passed a lead car. Following this sequence each subject was administered a pretest, involving an oncoming scene film during which the subject was to press a switch when he believed the last possible moment for passing had arrived. Then in followup film sessions one group of subjects received instant feedback on each performance while a second group did not. Analysis of the data showed that there was a significant correlation (.57) between the on-the-road and in the lab performance on this type of task. It was also found that subjects receiving the feedback improved significantly in a posttest measure while the other group failed to improve in accuracy of passing judgment. (Author)

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AN EVALUATION OF THE TRAINING OF A CRITICAL DRIVING SKILL BY MEANS OF A SIMULATION TECHNIQUE

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SUMMARY

Fifty subjects were tested and trained by means of a simulation technique to determine if drivers could be taught to make accurate last minute passing judgments and if knowledge of direction (too early or too late) and magnitude of error on individual trials would have any influence on this training. Thirty-two of the fifty subjects had previously been run in an on-the-road study and were used in the present investigation so that a correlation could be calculated between untrained on-the-road estimation ability and pretraining trials.

The subjects were divided into two groups with random assignment to groups. One group received feedback concerning error in the simulated task and the other did not. The training and testing procedures were as follows: Individuals were brought into a projection room and shown 47 scenes in which a camera car, in which the subject was supposedly riding, actually passed a lead car. The subject saw a view through the windshield, looking at the road ahead. After this film was viewed, each subject was administered a "pretest." In this test, an oncoming scene film was shown. The film consisted of thirty-five scenes in which vehicles approached the camera car, which was following the same lead car as before, and eventually met and passed the camera car. The task of the subject was to press a switch when he believed the last possible moment for passing had arrived, as based on the passing ability demonstrated in the first film.

In a second film session, using the same thirty-five scene film, the differential "treatment" was administered. A subject in the "knowledge of results" condition saw a red or green signal light when he pressed his switch telling him that he had estimated too late or too early, respectively. In addition to these lights, the experimenter verbally informed him on each trial, how late or how early, to the nearest hundredth of a second, his estimation was on that trial. The rationale here was that the subject could use this information to correct himself on following trials.

Subjects in the "no knowledge" condition, however, were simply shown the oncoming film a second time and instructed to continue responding as in the first oncoming session.

Following this "treatment" session, all subjects were shown the oncoming scenes for a third time. Each subject was instructed to respond to the film as he had in the first of the three sessions, i.e. the session with no error information.

Analysis of the data showed that there was a significant correlation (.57) between the on-the-road and in the lab performance on this type of task.

Analysis of the film data showed, via interaction effects, that subjects who received knowledge of their performance results on each trial improved significantly in a posttest measure while those receiving no knowledge failed to improve in accuracy of passing judgments. In the posttests, the subjects who had received feedback were also significantly more accurate than those who had not received feedback. It was also found that there was a tendency for variability of judgments to be reduced in the posttest for those subjects receiving knowledge of their performance on each trial.

Finally, it was suggested that future research investigate what variables in a film scene influence the accuracy or lack of same in making passing judgments of a last minute variety.

INTRODUCTION

In recent literature in the area of Safety Education there has been an increasing amount of skeptical comment regarding the usefulness of driver education. However, recently there has also been greater legislative and financial support for the driver education programs than has been evidenced in the past. Goldstein (1969) points up this conflict in a review in which he states that persons who present available data as offering support or condemnation of current driver education programs are in error. The data are of such a nature that conclusions may not be drawn from them.

Perhaps one of the most important causes of the current methodological distress is due to the complexity of the driving task itself. Data dealing with the intricate nature of operator requirements have been sought for some time, and only recently are breakthroughs in the area of driver task requirements being made (Ellingstad, 1969). In light of the complexity of this task, perhaps more useful outcomes could be obtained by testing and training only a part of the driving behavior of the subject. The rationale for such an approach has been stated by Michaels and Stephens (1963) in a paper dealing with the use of part-task simulation in driving research. By using such an approach for the study of driver behavior, the researcher is allowed the flexibility afforded by comparatively simplified instrumentational requirements. There is also the

advantage of being able to study and train, in the laboratory, some of the crucial skills isolated from the total driving situation. Such part-task simulation techniques can vary in stimulus and response fidelity, without necessarily influencing the validity of such techniques. A further advance in the study of part-task simulation has been made through the use of computers which simulate both the environment and the driver, using programs which generate data on the interaction of these two variables from a mathematically theoretical point of view (Braunstein, Laughery & Siegfried, 1963). A large number of part-task simulation techniques have been used. One particularly relevant technique, although not specifically involved with simulation, was used by Brody (1960). In this study, Brody used a specially produced "instructional film" to train subjects on selected simple driving skills. In general, then, research of the future must concentrate on whether or not classroom instruction on critical skills will be of help to the emergent driver when he begins operating on the public highways, how these skills are to be taught, and which skills can be trained most effectively in an off-the-road setting.

One of the critical skills involved in the driving task is that of overtaking a lead car safely. The "accelerative pass" has been studied in relation to many variables such as knowledge of oncoming car speed (Farber & Silver, 1967); lead car speed (Farber & Silver, 1967); day versus night conditions, (Farber, 1969); sight distance and speed imedance (Hostetter & Seguin, 1969).

In addition to the aforementioned "environmental" variables, certain subject-oriented variables in the passing situation have also been investigated. Crawford (1963) conducted one of the first "psychological" studies of the driver in a passing situation. By studying what he called "threshold conditions" (where a pass-no pass decision is hardest to make) in relation to the passing interval offered, response time, overtaking time and "safety time," or time between the completion of the overtaking driver's own pass and the arrival of the approach car abreast of him, Crawford defined parameters which relate to the occurrence of passing behavior.

An older study of passing behavior has also been reported by Forbes and Matson (1939) in which a number of different variables were considered. They discovered a critical minimum overtaking rate for the completion of "flying passes," measured "clearance time" after

passes and compared these variables over different geographic locations. They noted differences between New England and Far Western drivers. With regards to these factors, the authors hypothesized, rather generally, the existence of certain psychological factors which operate to influence passing behavior of different drivers in dissimilar geographic locations.

The most recent general study of driver behavior in passing situations has been reported by Gordon and Mast (1968). In their study of drivers' decisions in passing, they were primarily concerned with distance judgment in passing situations in their own cars and in experimental "government cars." The results of this study showed that persons were unable to correctly estimate overtaking distances (which involves the performance of mathematical integration, a function at which the human operator is typically poor) and that these distances increased with increasing relative approach speeds. Because of this fact, taken in conjunction with the knowledge that as decisions become nearer to the "critical level" (yes-no crossover point) they consume more time (Crawford, 1963), further investigations into passes at the "last possible passing moment" have been undertaken.

Most recently, an experiment by Farber and Silver (1967), dealt with the variation of both lead car and oncoming car speed, in conjunction with either no knowledge, verbal knowledge or repeated trials at the same oncoming car (OC) speed as these affected the accuracy of passes. These passes, according to instructions, were to be attempted at the last possible safe moment. The results of these studies showed that the persons who received knowledge of the oncoming car's speed showed less variance in their behavioral estimate of the last possible passing moment. This was demonstrated in their relatively consistent passing point under these conditions. Furthermore, both knowledge and no knowledge groups showed less variance in their estimates at HIGHER oncoming car (OC) speeds. However, with their concern for variances of the estimate distribution, the authors overlook the question of accuracy of estimation.

A 1964 study reported by Jones and Heimstra takes as its main concern the study of the ability, or more precisely, accuracy of drivers in making critical "last minute" passing judgments. In this study, they were concerned with the small percentage of passes noted by

Crawford to be unsafe, i.e. where the oncoming or passing driver was forced to take evasive action in order to avoid a head-on collision.

In an on-the-road survey type of study, Jones and Heimstra used the following procedure: On an open stretch of highway with a lead car traveling at 60 mph, the subject was allowed to familiarize himself with his own vehicle by completing eight maximum-acceleration practice passes. Times were recorded for the completion of each of these passes. Following this section, the subject watched approaching cars and estimated, by saying "now," the last possible passing moment (without actually passing the lead car). Time was recorded from the moment that the subject indicated, verbally, the beginning of the passing opportunity until the approaching car came abreast of the lead car. This was called the clearance time estimate. In all, ten of these experimental estimates were obtained for each subject.

In their analyses of the data, Jones and Heimstra used both the mean actual passing time for each subject and the fastest single passing time for that subject as a correction factor in determining over- and under-estimates of passing time. This correction factor was subtracted from the clearance time estimate of a subject. For example, if the correction factor was 8 seconds and the clearance time estimate was 10 seconds, an overestimate of 2 seconds was recorded. However, if the clearance time estimate was only 6 seconds, then an underestimate of 2 seconds was noted. When the results were examined, it was found that in using the mean passing time as a correction factor, nearly half of the estimates made by all subjects were underestimates, i.e., estimates which would have resulted in collision. The use of the fastest actual time as a correction factor reduced this somewhat, but still one third of the estimates would have produced evasive action at least, and possibly much more disastrous consequences had the pass actually been attempted. Results were found to vary considerably with some drivers being overly cautious in their estimates while others took considerable risks. The mean of the within driver standard deviations ranged around 2.75, showing the estimates to be more stable within than between drivers.

In their discussion of the results, Jones and Heimstra conclude that, in terms of the ability of drivers to make critical passing judgments of this type, they cannot make the judgments accurately. Though the

authors are willing to admit to the fact that this type of situation is a rare one, indeed, it is also one which could have the most undesirable outcome if performed incorrectly.

There are a number of investigators who believe that the ability of drivers to make this type judgment could be improved. The key question is whether or not the improvement can be made by means of training procedures or by means of elaborate sensing and display equipment mounted in vehicles. This equipment, which would be designed to give information to the driver concerning speed of oncoming vehicles, has been advocated by Farber and Silver (1967). Obviously, this would be an expensive approach with no assurance that drivers would make use of the equipment even if all vehicles were so equipped.

It would appear that training for this particular skill would be a cheaper and, possibly, a more effective approach. In considering techniques for utilization in training of this type, however, several factors must be taken into consideration. The basic question is whether training should be accomplished "on the road" or in the laboratory. While on the road training would have the advantage of realism except in specialized cases, it would probably be impractical in terms of the potential hazard involved and in terms of the limited number of individuals who could be trained in a reasonable amount of time. On the other hand, if it is possible by means of simulation techniques to train drivers in this skill, the above objections are overcome.

A decision to utilize simulation techniques, however, raises additional questions. For example, the question of the type of simulation, i.e., part or whole task, which could be used most effectively must be considered. Questions regarding cost, availability, capability for training large numbers of students, technical support required, etc. must be considered. Based on careful evaluation of the above factors as well as others, it was decided to develop a part task simulation situation which would involve the use of films. This type simulation is not only relatively inexpensive but also can be utilized to train large numbers of trainees simultaneously. In addition, if this method proved to be successful, with some modifications it could be used in many existing training programs that make use of film simulators.

The specific aim of the present investigation, then, was to develop and evaluate a simulation technique designed to train drivers in a critical driving skill.

METHODS

Basic Design

The primary task of the subject was to respond to certain filmed scenes by means of a hand held switch. These scenes were divided into two basic types. In the first section of film scenes, the subject watched as the camera car, in which he was supposedly riding, passed a lead car. The view of this activity, as presented to the subject, was through the driver's portion of the windshield of the camera car, looking forward. In the remaining sections of film, the second type of scene was seen by the subject. In these, with a similar forward view, the subject saw a lead car in front of the camera car, traveling at a steady speed and distance ahead, while other vehicles approached the lead and camera cars in the oncoming lane of a two-lane highway and eventually passed by.

The first section of scenes, subsequently referred to as the passing scenes, were simply watched in the experiment by each subject. The individual actively responded to the second type of scene, the oncoming scenes, by estimating the last possible passing moment as based on the passing scene information, and, in some cases, on feedback error information provided by the experimenter. This will be further explained in following sections.

Filming Procedure

In the filming of the two different types of scenes, a standard lead car, a 1967 Pontiac Tempest, and a standard camera car, a 1966 Ford Fairlane were used. The camera car was equipped with a 315 horsepower engine, allowing rapid passes in the passing film.

The passing scenes for the study were filmed on Interstate route 29 between Junction City and Lennox, South Dakota. With the lens of the camera in the camera car placed at the normal driver's eye position, a number of accelerative passes were filmed. At the start of the pass, the lead car maintained a constant speed of 60 mph and the driver of the camera car accelerated, passed, and returned to the traveling lane of traffic as quickly as possible. Approximately seventy of these scenes were taken, with 47 being retained for final use.

In making the oncoming film, the camera car followed the lead car on certain state and federal roads in southeastern South Dakota and Northwestern Iowa. These roads offered optimal backgrounds and sight distances in conjunction with variations in gradient and curvature of the highway surface. Both vehicles again traveled at 60 mph. When approaching vehicles came into view with at least an approximated 12 seconds headway between approach and lead vehicles, the camera in the camera car was started. The camera position was maintained in the driver's eye position, allowing the wide angle lens to photograph the lead vehicle as well as a clear view of the oncoming vehicle. In all, over 200 of these scenes were filmed and thirty-five were selected and retained for final use in the study.

Film Preparation

After processing, the passing scenes were edited for clarity and spliced together into a continuous film involving 47 scenes. Following this, these scenes were analyzed individually regarding the number of frames intervening between the point when the front left wheel of the camera car entered the passing lane of traffic until this wheel returned to the traveling lane. By this method it was determined that 87 frames, on the average, were required for the camera car to pass the lead car. At a film speed of 16 frames per second, this came out to be slightly more than 5.4 seconds passing time.

After a number of factors were considered, thirty-five oncoming scenes were selected from the total number. Three seconds of blank leader was inserted between each scene, all were spliced together and a copy made. The copy was made on sound film with a blank sound track. When the film was returned, it was prepared for subject testing.

In modern sound-on-film 16 mm motion picture projectors, the sound track is advanced 26 frames over the picture. Therefore, in the preparation of the film, the experimenter determined the point where the approach vehicle came abreast of the lead car on the film and counted back 113 frames (87 for the pass and 26 for the advance) where a small 1/16" hole was drilled in the sound track. Then, when the film was projected, a sound signal occurred at the precise last possible passing moment on the film as determined from the passing scenes. These marker holes were made for all thirty-five oncoming scenes.

Apparatus

The apparatus was constructed in a rectangular (8' x 18') room with adequate light shielding to use for projection purposes. At one end of the room was a small (2½' x 3') screen and a subject chair, close to the surface of the screen but at such an angle that the subject would not be in the path of projection. On a table behind the subject was placed a Bell and Howell model 552 Filmosound projector. The lens aperture was placed approximately nine feet from the viewing surface and the image covered nearly all of the surface area of the screen. Directly above the center of the screen were placed two colored (red and green) ten watt 110 volt signal lights. These were used in certain sections of the experiment to indicate to the subject direction of error of estimate. The red bulb was intended to indicate a late response (underestimate) on the part of the subject, while the green bulb signaled an early response or overestimate.

The recording and control sections of the apparatus were located at the far end of the room from the subject. This device received inputs from the sound output of the projector (which disabled the speaker of the projector), from a subject switch and from an experimenter switch, used to reset the apparatus after each trial. Outputs of the device controlled power to the signal lights as well as those to two Standard Electric timers which indicated, to the experimenter, direction and magnitude of error.

During the projection of the oncoming scenes, if the subject responded prior to the arrival of the sound track marker, timer #1 went on and stopped when the sound track did respond. In addition, in the feedback section of the study, a green light of short (.6 second) duration came on simultaneously with the early response. However, if the film track responded first, it started the #2 timer, which was stopped by the subject's late response. Once again, in the sections of the study involving feedback to the subject, the response would trigger a 6/10 second light. However, in this situation it was a red light, indicating a late response.

The logic section of the apparatus was programmed with solid-state electronic modules which controlled electromechanical relay equipment handling external outputs.

Procedure

After arriving at the laboratory, the subject was asked for pertinent personal information, address, phone, length of driving experience, etc. After each individual had furnished this information, he was seated in the subject chair and read the first set of instructions:

> The film that you are about to see indicates the passing capabilities of a car in which you are supposedly riding. There are 47 scenes in this film in which the camera car, the one in which you are now riding actually passes a lead car. Please sit and watch these films carefully and try to get some idea as to just how quickly the lead car can actually be passed. By a pass is meant the time from which the camera car enters what would be the lane of approaching traffic until the time that it returns all four wheels to its own lane of travel. You will later be asked to make judgments based on the information that you get from this film, so please watch closely. Do you have any questions?

All of the subjects were read this first set of instructions. All then saw the passing film which ran slightly longer than six minutes.

Following this first set of films, the remainder of the experimental equipment was activated and the oncoming film was loaded into the projector. This was in preparation for the film "pretest" which was also administered to both groups. After the equipment was ready for operation, the following set of instructions was read to the subjects.

> In this section you will see from the camera car, a lead car in front of you. In the oncoming lane of traffic, you will see vehicles approaching from a distance, and they will keep on coming until they have come abreast of the lead car and pass on. When this happens, the trial is over. Here is what I want you to do in this section of the experiment: take this switch (The subject is shown its operation) and press it when you think the very last safe passing moment has arrived. Press the switch once, but not more than once during each trial.

You will know that a trial is over when you see a white, blank screen for three seconds. The next trial will start three seconds after the screen goes blank and there are thirty-five trials in all in this section. Once again, watch the approaching vehicle and press the switch at the very last moment at which you think the camera car could pass the lead car without colliding with the approach vehicle. These judgments should be based on the information that you gained from the passing scenes that you just watched. These events occur quite rapidly, so pay attention to the approach car and press the button briefly at the right time. Disregard passing lane indicators, other vehicles in front of the lead car and so forth. Do you have any questions?

After any difficulties associated with the instructions were resolved, the experimenter started the film and went to the rear of the room to record times and reset the device as necessary. When this section was completed, the subjects were asked to remain seated and the film was rewound and again loaded into the projector.

It is at this point that the experimental treatment was given. In the case of one group of subjects, called the no-knowledge group, no specific set of instructions was read. Instead, they were simply told that the experimental design called for a second showing, with accompanying subject responses to the film. The film was then run through for the second time. For a second group, (knowledge-of-results or "feedback" group) however, the feedback signal lamps were activated and the following instructions read:

In this section of the experiment, you will be seeing the same film with the approaching cars that you saw the last time, but in this section there will be something new; now, as soon as you make a response, one of the lights above the screen will come on. If you responded too early, that is, if you still would have had more time after making your supposed pass before the approach vehicle met you, the green light will come on for six-tenths of a second. If you responded too late, your response will be accompanied by the red light of a similar duration (six-tenths of a second)and this will indicate that, had you passed, a head on collision

would have resulted. In addition to this light information, I will also tell you, loud enough for you to hear, the amount of time, in seconds, that you were off, early or late. I will give you this information to two decimal places. For example, after the timer stops, I might say "one point five three late." That means that you were about a second and a half late on that trial. The important part of this section is that you take into consideration the information that I give you and try to correct yourself on the next trial. I realize that it is almost impossible to get a perfect score, but you should try to keep the error in seconds as small as possible. Here let me stress the importance of a strong but brief response. At times, when you are very close to the mark, but slightly early, both lights will go on. This is acceptable to some degree, but the longer your responses are, the more likely this is to happen, thus costing you the value of the immediate information offered by the lights. This is not a test of speed of response to the switch, but only of passing judgments. However, try to make brief responses that you are sure are strong enough to register. Remember, make your passing judgments using the switch as you did before, but USE THE INFORMATION THAT I GIVE YOU TO TRY TO CORRECT YOURSELF. THIS IS VERY IMPORTANT! As in the last section, there are thirty-five scenes in this part also. All of these scenes happen, as you know, quite quickly and THIS TIME you must consider the error which I will give you as soon as the timer stops. Therefore, please pay close attention to the task which you must perform. Do you have any questions?

After any questions were answered, the film was started and the experimenter went to the rear of the room and recorded, as well as verbally repeated, the time errors and the direction of the error. After this second section was run, subjects in both groups were again instructed to remain seated, the film rewound and reloaded.

The last section of the experiment was considered as a posttest to compare the effects of presence or absence of feedback upon performance. The subjects were shown the same film a third time under conditions similar to the first showing. The following set of

instructions was read to subjects in both groups. The section in parentheses was not read to the no-knowledge group.

> In this section you will have an opportunity to show whatever you might have learned. We will go through the thirty-five film scenes again and we want you to use the switch the same as before. (This time you will receive no lights and no time-error reports.) This is the last session of the experiment, and perhaps the most important. Here, if you have received any beneficial training from this experiment the results will show up. I realize that you might be getting bored from watching this film, but your continued attention in this last section is more important than ever before. Please watch and judge carefully through these thirty-five scenes, and then we will be finished. Do you have any questions?

The film was then run one last time and the subject was dismissed.

Subjects

A total of 50 undergraduate male students at the University of South Dakota were used as subjects. Twenty-five were assigned to each of the two groups. All subjects were holders of valid drivers licenses. Thirty-two of the subjects (16 per group) had been run in a previous on-the-road study which involved making estimates of clearance times in a passing situation. It was believed that such prior participation would not affect performance on the current study. All subjects were paid to take part in the investigation.

Measures Obtained

The apparatus described earlier allowed the instantaneous collection of error scores on the readout. Data were recorded as to direction of error. As a result, simplified computation of constant error scores as well as absolute error scores attributable to all subjects could be made. The actual time estimate of each subject on each trial could be recovered by simply adding 5.44 to every score.

In addition, as previously mentioned, on the road estimates by 32 of the 50 subjects were also available from a previous unpublished study. The mean constant

and absolute error scores of these subjects were also used to determine how the laboratory data related to the on-the-road performance.

Data Analysis

The data from the study were analyzed in several different ways. The primary statistical techniques utilized were analysis of variance and correlations. Absolute and constant error scores were analyzed in separate but identical fashions. Data were first subjected to analysis in a three factor analysis of variance with repeated measures over two (feedback condition X pre-posttest levels X trials, repeated over the last two factors). Following this, data were split so that two two factor analyses with repeated measures over one factor could be done for each of the two levels of pre-posttest levels (feedback condition X trials, repeated over trials). Additional two factor analyses with repeated measures over both factors were carried out for both feedback conditions (pre-posttest levels X trials). In addition to these techniques, correlation coefficients were calculated between the mean error scores of the ten on-the-road estimates of thirty-two of the subjects with the mean error scores of the first ten pre-test trials recorded in this study for the same subjects. This operation was performed to establish the presence or absence of a relationship between on-the-road performance and the lab-film technique with regards to passing judgment accuracy.

RESULTS

Absolute and Constant Error

After all data analyses were completed, the results produced by analyzing constant error and those yielded by using absolute error were compared. It was noted that analyzing the data in both manners (with or without regard to the direction of error) yielded significance in identical factors and interactions and at the same level (.01). In light of this similarity, the presentation of both sets of data accompanied by two explanations would be redundant. Since the primary concern of this study was with the accuracy of judgments rather than safety (over or underestimate), summary tables, correlation and figures for only the absolute error scores are presented.

Analyses of Variance

The summary table for the analysis of variance of all film data is presented in Table I. It can be seen that the effect for knowledge versus no knowledge (A) is not significant. In the same summary table, however, the effect for pre- versus posttests is shown to be significant. In addition to this, the second order interaction of these two factors is also found to be significant beyond the .01 level.

Figures 1 and 2 illustrate the workings of factors A and B in this study. With regard to knowledge condition, inspection of the center plot in Figure 2 indicates that there is, indeed, very little difference between the two conditions when each is averaged across combined pre- and posttests. Inspection of the middle plot in Figure 1, on the other hand, reveals that there is a substantial difference between the pre- and posttest scores when all groups are considered together. This explains the significant difference between these two test conditions in the total data analysis.

More interesting, and perhaps more meaningful, is the intersecting and opposing nature of the single level plots shown in Figures 1 and 2. These both contribute to the explanation of the significant interaction effect. That is, it can be seen that the error score on one level of factor A or B is clearly dependent on the level of the accompanying factor.

In order to determine precisely the source of this interaction, four separate "sub-analyses" were conducted over each of the two separate levels of the knowledge (A) condition and each of the two test (B) conditions. Tables II and III contain the summary information gained from these analyses.

Referring first to the A1 section of Table II, a significant B effect is revealed. Logically, this indicates that for the knowledge-of-results subjects there was a significant improvement in the ability to estimate the last possible passing moment when the post- and pretests are compared. This can be seen graphically in the appropriate ("knowledge of results group") plot in Figure 1.

Secondly, inspection of the A2 section of Table II is required to explain the AB interaction. Here the B effect is non-significant. The logical interpretation of this result is nothing more than that for the no knowledge subjects, there is no improvement in the ability to make

Table I

Summary Table for the Analysis of Variance
of Absolute Error Scores
(All Data)

Effect	SS	df	MS	F
A (feedback condition)	37.03	1	37.03	<1.00
Subjects within groups	3160.70	48	65.85	
B (pre-post tests)	963.19	1	963.19	25.09*
AB	496.09	1	496.09	12.92*
B X Subjects within groups	1842.74	48	38.39	
C (trials)	4720.40	34	138.84	30.85*
AC	137.18	34	4.03	<1.00
C X Subjects within groups	7344.40	1632	4.50	
BC	2092.92	34	61.56	19.18*
ABC	306.67	34	9.02	2.81*
BC X Subjects within groups	5242.34	1632	3.21	

*p < .01

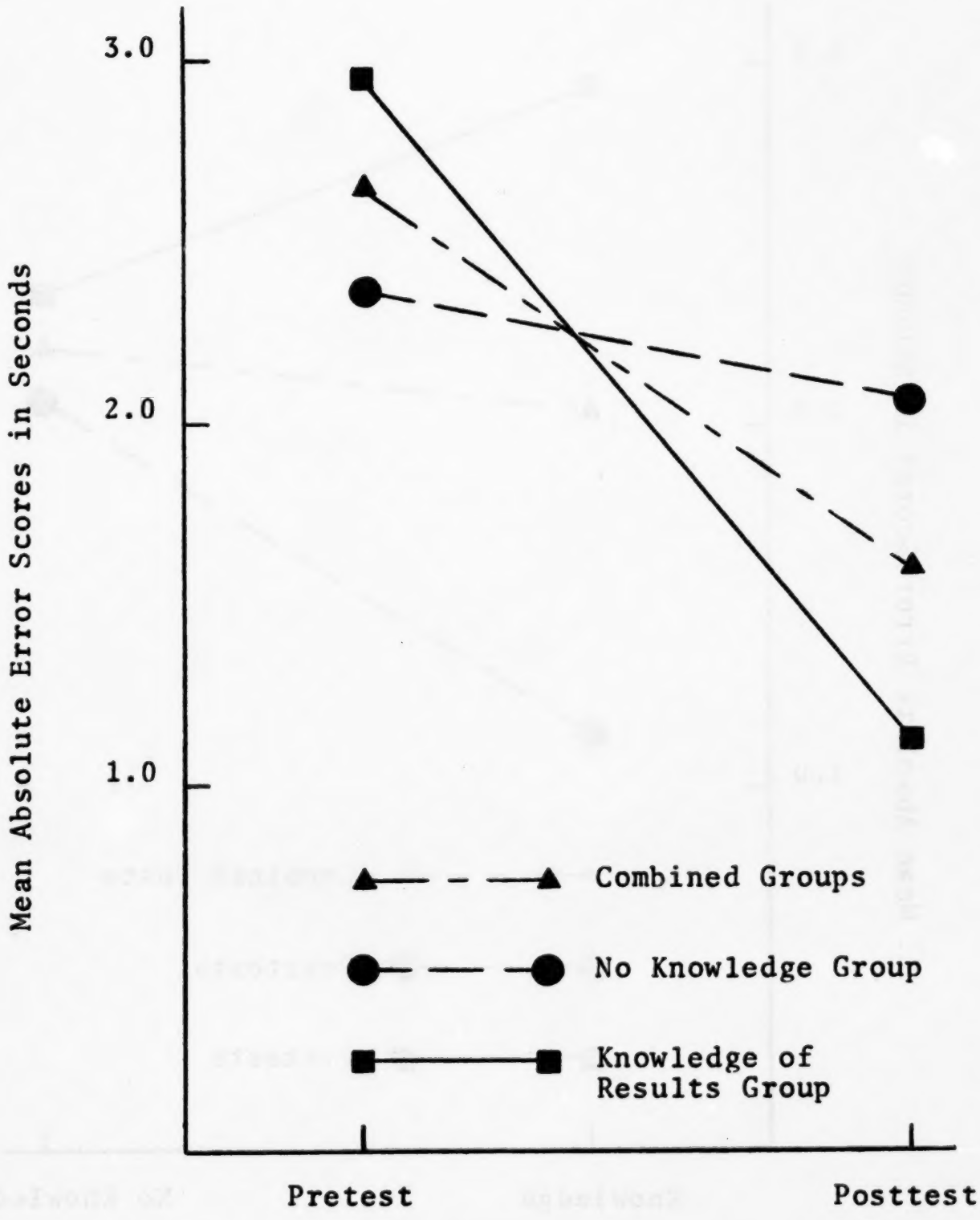

Figure 1.

Error Scores For Levels of Factor A Plotted Over Levels of Factor B

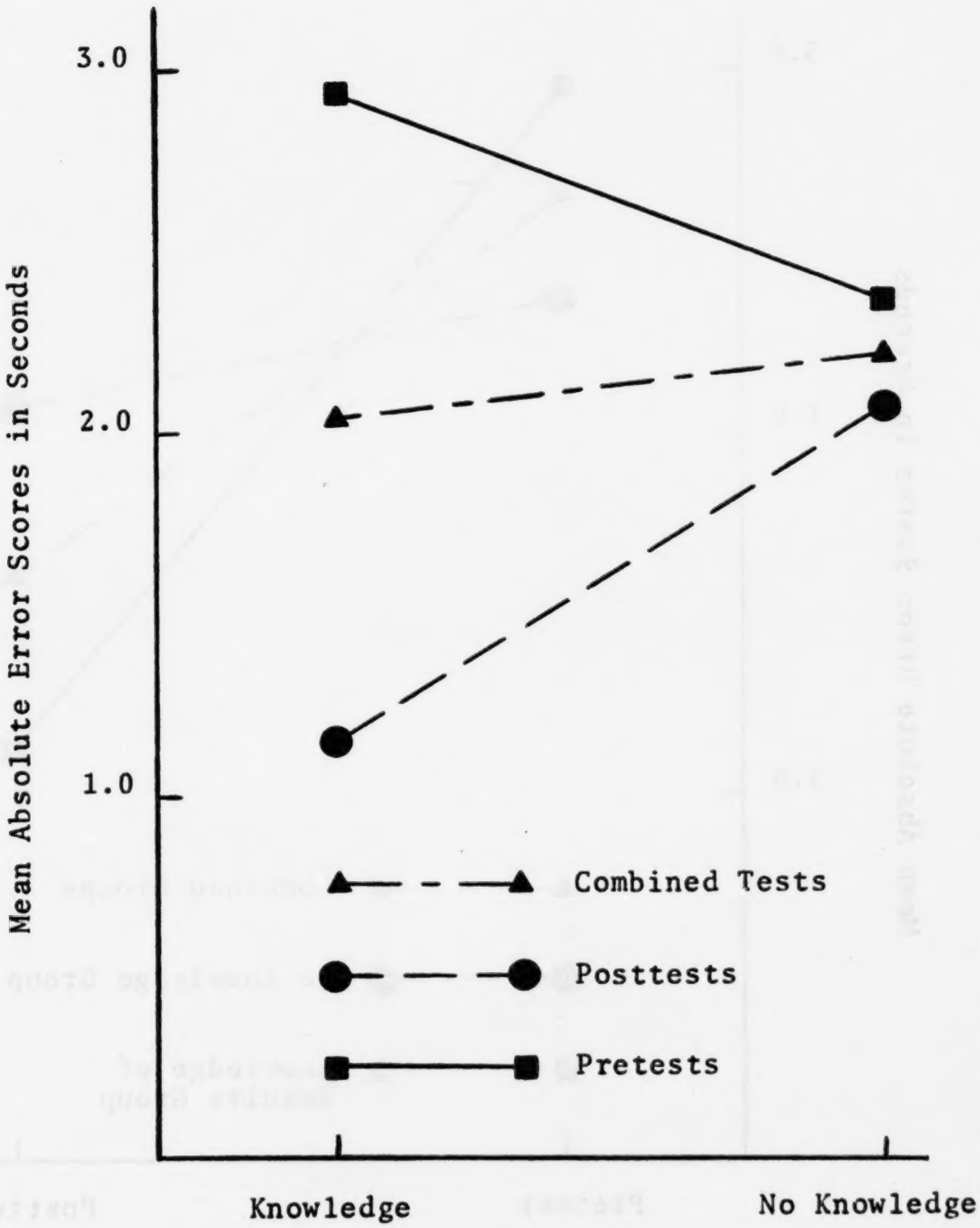

Figure 2.

Error Scores For Levels of Factor B
Plotted Over Levels of Factor A

Table II

Summary Tables for Analyses of Variance
of Absolute Error Scores
(Separate Levels of Factor A)

A_1

Effect	SS	df	MS	F
B	1423.92	1	1423.92	22.75*
B X Subjects within groups	1502.25	24	62.59	
C	2760.36	34	81.19	19.97*
C X Subjects within groups	3317.88	816	4.07	
BC	1388.57	34	40.84	11.47*
BC X Subjects within groups	2905.21	816	3.56	

A_2

Effect	SS	df	MS	F
B	35.34	1	35.34	2.49
B X Subjects within groups	340.48	24	14.19	
C	2097.21	34	61.68	12.50*
C X Subjects within groups	4026.69	816	4.93	
BC	1011.06	34	29.74	10.38*
BC X Subjects within groups	2337.62	816	2.86	

*$p < .01$

A_1 = over knowledge of results group
A_2 = over no-knowledge group

passing judgments when the pre- and posttest are compared. In relation to this finding, inspection of the "no knowledge group" plot in Figure 1 reveals a slight improvement. However, the effects of intersubject variability are sufficient to keep this effect from being significant.

Turning to Table III, analyses over separate levels of the test condition are summarized. In level B1 of this table, no significant difference is found in the levels of the knowledge conditions. This nonsignificance of the A effect is logically consistent with the assumption of random subject selection. The lack of significant difference indicates that before any treatment was administered, i.e. on the pretests, that there was no difference between subjects not attributable to chance. In reference to this, the upper plot of Figure 2 indicates some difference between the two groups. This, however is calculated from mean scores and when the variability of the scores is taken into account, any nonchance explanation of this difference is ruled out.

Level B2, in the lower half of Table III analyzes effects in the posttest section of the study. Here, a significant A effect is found. This indicated that in the posttests, the error scores of the knowledge-of-results group are lower than the corresponding scores of the no knowledge group, and they are lower to a significant degree. The lower plot in Figure 2 graphically represents this difference.

In summary, the above results indicate that from an initially equal ability to make passing judgments the knowledge of results group improves and the no knowledge group fails to improve. This results in significantly better performance by the knowledge group on the final test.

In addition to the significant B and AB effects, throughout all of the five listed summary tables, a significant C effect, which is a trials factor, is seen. In terms of the manipulated variables, this significance is of little importance. In the inspection of Table IV, which gives trial mean scores for combinations of A & B, it will be noticed that certain trials, such as numbers 3, 7, 13, 19, 22, 28, 33 and 34 show considerable and consistent confusion to the subject as indicated by the elevated error scores. An inspection of the oncoming film reveals that certain vehicular, lighting, background and environmental variables could act in these scenes in such a way as to lower the accuracy of the subject's

Table III

Summary Tables for Analyses of Variance
of Absolute Error Scores
(Separate Levels of Factor B)

B_1

Effect	SS	df	MS	F
A	154.08	1	154.08	1.88
Subjects within groups	3937.78	48	82.04	
C	6207.09	34	182.56	32.20*
AC	199.24	34	5.86	1.03
C X Subjects within groups	9253.18	1632	5.67	

B_2

Effect	SS	df	MS	F
A	379.04	1	379.04	17.07*
Subjects within groups	1065.67	48	22.20	
C	606.42	34	17.84	8.75*
AC	244.47	34	7.19	3.52*
C X Subjects within groups	3334.79	1632	2.04	

*$p < .01$

B_1 = over pretests
B_2 = over posttests

	A_1B_1	A_1B_2	A_1	A_2B_1	A_2B_2	A_2	B_1	B_2	Oall
1	1.67	0.90	1.29	1.77	2.11	1.94	1.72	1.51	1.62
2	3.65	2.01	2.83	2.86	2.89	2.87	3.26	2.45	2.86
3	6.29	1.97	4.13	3.44	4.52	3.98	4.87	3.25	4.06
4	1.63	1.19	1.41	1.78	1.45	1.61	1.71	1.32	1.52
5	1.90	0.58	1.24	1.53	1.78	1.65	1.72	1.18	1.45
6	2.81	1.05	1.93	1.71	2.33	2.02	2.26	1.69	1.98
7	3.87	1.77	2.82	3.64	3.46	3.55	3.76	2.62	3.19
8	1.26	0.74	1.00	1.03	1.66	1.35	1.15	1.20	1.18
9	1.64	1.17	1.41	1.54	1.13	1.33	1.59	1.15	1.37
10	2.19	1.06	1.63	1.78	1.65	1.72	1.99	1.36	1.68
11	2.57	0.90	1.73	1.54	1.00	1.27	2.06	0.95	1.51
12	1.69	0.85	1.27	1.29	1.21	1.25	1.49	1.03	1.26
13	2.68	1.70	2.19	2.55	2.19	2.37	2.62	1.95	2.29
14	1.89	0.69	1.29	1.38	1.23	1.30	1.64	0.96	1.30
15	1.79	0.97	1.38	1.28	1.38	1.33	1.54	1.18	1.36
16	1.64	0.79	1.22	1.22	1.33	1.27	1.43	1.06	1.25
17	3.71	0.92	2.32	2.16	1.74	1.95	2.94	1.33	2.14
18	2.22	0.39	1.31	1.46	1.48	1.47	1.84	0.94	1.39
19	3.56	2.24	2.90	3.05	2.91	2.98	3.31	2.58	2.95
20	2.71	1.04	1.87	2.49	3.51	3.00	2.60	2.28	2.44
21	1.32	1.03	1.18	1.39	1.44	1.41	1.36	1.24	1.30
22	4.43	0.94	2.68	3.98	2.58	3.28	4.21	1.76	2.99
23	1.22	1.01	1.12	1.63	1.09	1.36	1.43	1.05	1.24
24	2.32	0.63	1.47	2.03	1.79	1.91	2.18	1.21	1.70
25	1.91	1.20	1.56	1.85	1.26	1.55	1.88	1.23	1.56
26	1.32	0.72	1.02	1.11	1.84	1.48	1.22	1.28	1.25
27	2.93	0.93	1.93	2.46	1.89	2.17	2.70	1.41	2.06
28	6.81	1.37	4.09	5.16	4.09	4.62	6.99	2.73	4.86
29	2.82	1.31	2.06	1.93	2.50	2.21	2.38	1.91	2.15
30	2.10	0.73	1.41	1.98	2.06	2.02	2.04	1.40	1.72
31	2.66	0.81	1.73	2.14	2.09	2.12	2.40	1.45	1.93
32	1.91	1.37	1.64	1.83	1.54	1.69	1.37	1.46	1.42
33	4.88	1.08	2.98	2.85	2.64	2.74	3.87	1.86	2.87
34	12.66	2.92	7.79	10.74	2.15	6.44	11.70	2.54	7.12
35	2.38	0.91	1.65	1.83	2.58	2.21	2.11	1.75	1.93

Table IV Absolute Error Means for Individual Trials Plotted Over Combinations of Levels of Prepost Test Factor (B) and Knowledge-No-Knowledge Factor (A).

judgments. Such factors as a large white grain elevator behind the oncoming vehicle, a bridge abutment appearing to be an oncoming vehicle, and a very dark sky were noted in some of these scenes. The conditions of the particular scenes probably forced the C effect to significance. Once again, this significance indicates merely that some scenes were more difficult to estimate than others and does not reflect on the trainability of the subjects.

With regard to the significant BC interaction, observance of raw data scores indicates that at level B2 (posttest) of the test condition, intersubject variability is lower than at the pretest level. It is this influence which is primarily responsible for the BC interaction. Again, this is not directly related to the training of the subjects on passing judgments.

Finally, the significant triple order interaction (ABC) in Table I can be explained best in terms of the double interactions found in the "sub-analyses" of Table II and III. Table II shows significant BC interactions under both levels of A, indicating that regardless of the knowledge condition, there is significant systematic interaction of factors B and C for reasons previously stated. However, in Table III, the AC interaction is significant only under level B2. Therefore, only under certain levels of B (B2) is an AC interaction meaningful and thus the systematic interrelation of three factors can be at least theoretically meaningful. Further explanation of so complex a relation, especially where its relation to the topic at hand is not perfectly relevant, will not be undertaken at this point.

Correlation: Road with Film

As mentioned previously, thirty-two of the subjects in the study had participated in an on-the-road type of study which involved their making critical passing judgments. For each subject, a "pretreatment" error estimate, averaged over ten on-the-road trials was available. For correlational purposes, the estimates from the first ten pretest film scenes were also averaged and a coefficient of correlation was computed. The data and relationship are explicitly outlined in Table V. The fact that there is a greater than chance relation of the two types of measures indicates the value of follow up on-the-road validation of this method of training for passing accuracy. The validation of this study could allow meaningful and proven incorporation of this

Table V

Correlation Data. Absolute Road Error Means Correlated With Means of First Ten Film Trials for Thirty-two Subjects.

Road Test	Film Test
4.21	2.03
3.71	2.01
4.51	1.67
3.74	1.04
4.48	1.86
1.45	1.01
2.02	1.07
.82	2.19
4.47	1.19
6.67	1.13
9.58	4.68
7.73	4.51
9.90	2.93
5.26	1.93
3.42	1.86
5.72	4.73
5.97	4.17
2.30	2.09
5.54	1.43
.97	1.25
3.44	.96
1.81	1.29
5.94	3.00
6.56	4.02
7.58	1.50
1.95	.69
2.43	1.41
1.63	1.61
1.77	2.48
2.38	3.24
5.15	2.36
.77	1.33

$r = .57$

$t = r\sqrt{(N-2)/(1-r^2)}$ $t = .57\sqrt{30/.675}$ $t = .57\sqrt{44.444}$

$t = 3.80$; $p < .01$, $df = 30$

technique into driver education courses. This correlation indicates simply that those individuals who are accurate estimators on the road also possess this capability in the laboratory. Inaccuracies on the road are reflected by high film error scores. Perhaps changed film scores (for the knowledge of results group) would also yield improved on-the-road scores.

CONCLUSIONS

The results of the present study represent what could become an ideally suited situation for a subtask type of off-the-road driver training. If a relation could be established between the final road performance and final film performance, then the incorporation of this type of training section could be very adequately justified on the basis of its proven utility. To some extent, the initial correlational data presented in the final portion of the preceding section does just this. It confirms a relationship, at least at the outset of training, of the road and film estimations made by subjects. Partial validation, at least, has thus been accomplished. The final confirmation of this relationship suggests fruitful research directions. It should be emphasized, however, that regardless of the impressiveness of the film results and the accompanying correlation which has been reported, it would be a hazardous venture to incorporate this method of training immediately. Far too often the area of driver education has suffered from hastily applied research results of questionable applicability.

With regard to the data which have been reported, however, the results are clear cut. Apparently, the ability to train drivers on the intact performance of a complex task is an achievable goal. The treatment variable, the feedback on error direction and magnitude, had the desired effect to a significant degree. Contrary to results reported by some investigators in the area of programmed instruction (Krumboltz and Weisman, 1962; Welsh, Antoinetti and Thayer, 1965) feedback information does have a significant improving effect.

More interesting in the examination of the results than any other single point is the significant knowledge x tests interaction. The significance indicated by this interaction and the significant effects which persist in the individual level analyses indicate something more than a simple practice effect occurring. The practical absence of a practice effect, in fact, is revealed by the lack of significant estimation accuracy improvement

in the no-knowledge group. Rather, the definite positive effect of the feedback supplied to the knowledge of results subjects is the sole reason for significant B and AB effects in the overall analysis. Only after the feedback training had been administered was any difference noted in pre- versus posttest performance or in the compared posttest performances of the two groups.

Primarily, the concern of the present study was with accuracy in passing judgments. It appears that at least in the off-the-road setting, that accuracy improvement has been accomplished. This finding can have two important implications for the driving public at large if it can be validated on the road. First, the improved ability to make last moment passing estimations with less error and less variability will also make driving safer. With a knowledge of his particular automobile's performance characteristics (this can be easily programmed into the training course) the individual will be able to pass without hesitation in safety. Crawford (1963) has found that hesitation in a difficult passing situation adds to the driver's reaction time, thus making the actual pass, if it is attempted, even more dangerous. In eliminating hesitation, as well as the likelihood of making a critical underestimation of the passing time with regard to the approach vehicle, the passing situation could be made safer. In addition, another benefit could be realized. By allowing the driver to know the car's capabilities in relation to certain oncoming vehicles, the driver could safely take advantage of passing opportunities which he would have previously rejected as overly risky when, in fact, they were not. Thus, in addition to making more safe passers, this sort of training could also produce more efficient ones.

With regards to hesitation and variation in making the go-no-go decision, it will be remembered that data inspection showed less intersubject variation in the case of the posttest measures of the subjects who received information on direction and magnitude of error. This reduction in variation could be due to the elimination of hesitation in decision making on the part of the driver, or at least a standardization of the hesitation factor after training. These are combined with increased accuracy, thus enabling the driver to treat his hesitation as a constant value (either zero or some small value greater than zero) when making the passing judgments.

Another interesting and meaningful finding with regards to the data has to do with the significant "trials" effect. As stated before, this has no direct bearing on the training in this particular study, but could have a bearing on future research in this field. Contrary to initial belief, simply the vehicle type approaching was not related directly to accuracy. Rather combinations of variables seem to have influenced the accuracy of estimation.

A meaningful course for a future project designed to investigate influential variables would incorporate film scenes with systematically varied light levels, approach times, roadside objects as well as vehicle types and approach speeds. If it were discovered that certain of these variables, either singly or in combination, have a detrimental effect on passing judgments, then the subject could also be trained to exercise added caution in these situations or, perhaps, taught not to attempt a pass at these times at all.

In conclusion, it seems quite obvious that this film simulation technique is not limited to simple passing situations. It seems that such a technique could be employed for any driving skill which is filmable and in which timing is a critical factor. Lane changes, emergency stop-or-steer situations, and skid control are only a few of the possible applications which are eminently feasible and practicable.

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